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# *Indian Standard*

# CODE OF PRACTICE FOR CONTROL OF AIR POLLUTION IN IRON AND STEEL PLANTS

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# *Indian Standard*

# CODE OF PRACTICE FOR CONTROL OF AIR POLLUTION IN IRON AND STEEL PLANTS

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# *Indian Standard*

# CODE OF PRACTICE FOR CONTROL OF AIR POLLUTION IN IRON AND STEEL PLANTS

## 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 28 March 1985, after the draft finalized by the Air Quality Sectional Committee had been approved by the Chemical Division Council.

**0.2** It is generally recognized that air pollution is emerging as one of the most significant and challenging environmental problems of modern society. The undesirable effects of air pollution on man, his property and possessions have given rise to an increasing degree of interest and concern on the part of the government, citizens and the industry.

**0.3** In an integrated iron and steel plant, facilities for coke making, ore preparation, sintering, iron making, steel making, continuous casting, rolling and finishing are the main production processes. Auxiliary installations comprise captive power plant, refractories material plant, foundry, etc. Each of these units, to a different degree, is a source of air pollution. A schematic diagram of all main sources of air pollution in an integrated works of the iron and steel industry is shown in Fig. 1.

**0.4** From the point of view of pollution of the atmosphere and habitation surrounding iron and steel plants, the large amount of dust laden gases emitted by these plants need prime consideration. This standard has been formulated in order to help the industry to identify the sources of pollution and to take suitable action for pollution abatement.

## 1. SCOPE

**1.1** This standard covers methods of controlling air pollution from various processes/sections of iron and steel plants. It includes information on generation of pollutants also.

## 2. RAW MATERIALS HANDLING

**2.1** ***Brief Description of Operating Process*** — A large quantity of raw materials are handled in an integrated iron and steel works. Dust is evolved

when unloading wagons, transferring materials, storing and reclaiming raw materials. Raw materials are usually received in wagons and unloaded by wagon tipplers or track hoppers over underground conveying system. Raw materials are transferred from the underground transfer points by belt conveyors to the various open storage yards through a number of junction houses. Materials are then reclaimed from open storage yards by stacker-cum-reclaimers and sent to the various sections by belt conveyors. Selective crushing and screening of raw materials are done at specific points in the material transfer circuit. Intermediate storage bunker houses for crushing and screening plants are often envisaged for assuring smooth material flow.

**2.2 Generation of Air Pollutants** — Dust is generated from the falling stream of materials in wagon tipplers and track hoppers, underground material transfer points and galleries, drop of material from conveyor to conveyor in junction houses, crushing and screening of materials, open storage yards, intermediate bunker charging and discharging points and all other points where material is physically disturbed.

**2.3 Measures to Control Air Pollution** — The concentration of dust in the working zone of dust generating points should be maintained within acceptable working zone concentration limits. For this, all the dust generating points should be enclosed and hoods installed for local exhaust ventilation. The extracted air should be cleaned in dry/wet type dust catchers in accordance with raw material characteristics. Wet type dust catchers should preferably be avoided. Dry type dust catchers may be cyclones, bag filters or battery cyclones with first stage dust catcher whenever required.

**2.3.1** In areas where local exhaust ventilation system cannot be envisaged, dust suppression by wet spray to harden the surface or material lumps should be provided. The moisture in the material may be limited to technically acceptable limits.

**2.3.2** In addition, to reduce the effects of generated dust, efforts should be made to minimize the formation of dust by modifying the process responsible for generation of dust. For this the following general measures may be taken:

a) Reduction of material transfer points,

b) Reduction of height of fall,

c) Reduction in belt speed,

d) Storage of materials in closed bunkers,

e) Reduction in crusher speed,

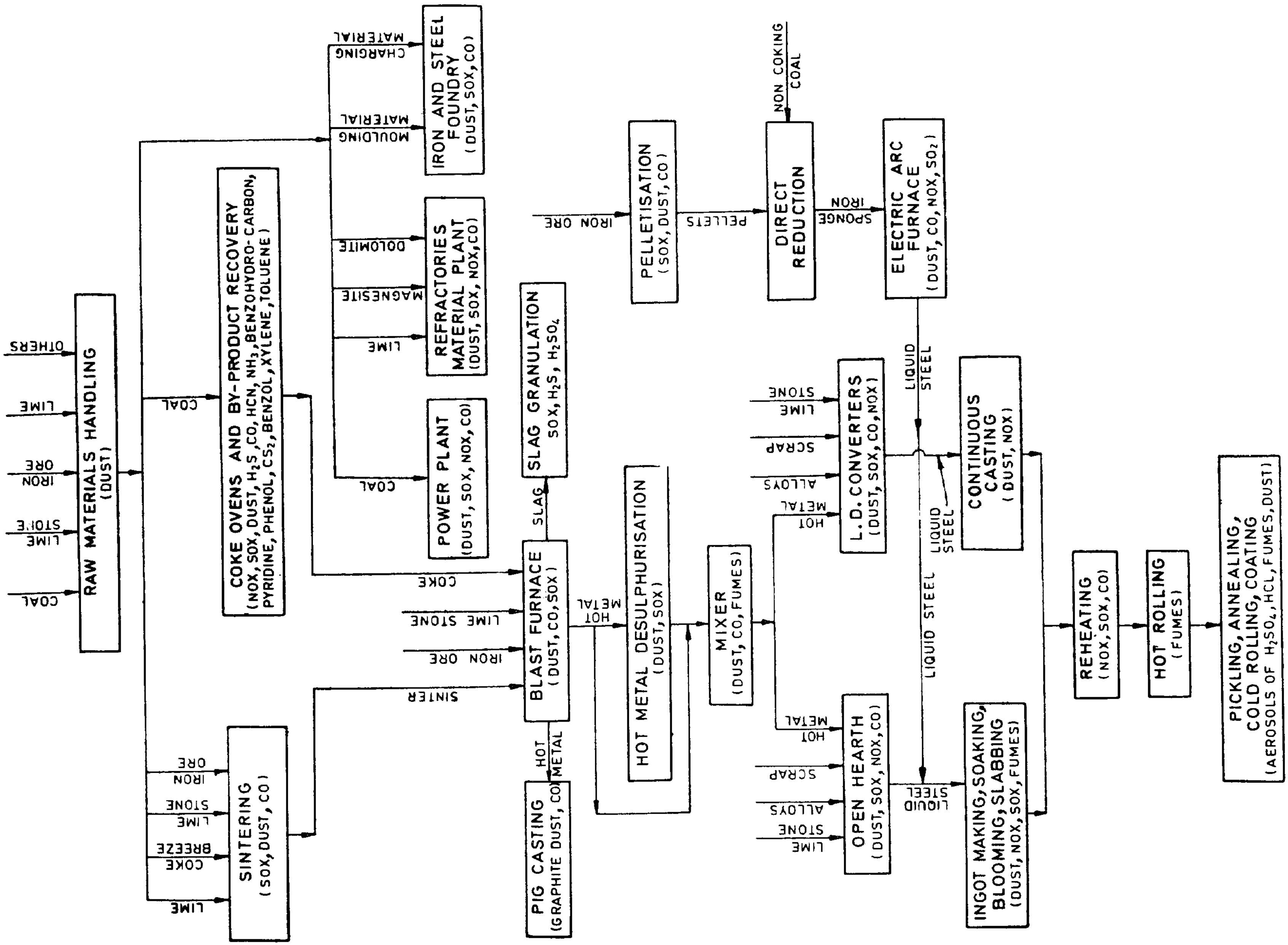


FIG. 1 SOURCES OF AIR POLLUTION AT INTEGRATED IRON AND STEEL WORK

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f) Provision of by-pass tube for hammer crusher for equalization of pressure-across crusher inlet and outlet, and

g) Proper enclosure of technological equipment.

**2.3.3** *Transportation and Storage* — Reduction in the number of transfers and the time required for each is the first consideration in a material handling air pollution abatement programme.

**2.3.3.1** Loading and unloading, conveyor belt discharge and transfer and stockpiling operations produce huge particulate matter emissions. Local exhaust ventilation system and wet sprays effectively control these emissions.

**2.3.3.2** Lack of attention to wind erosion of stockpiles often creates 'air pollution control paradox'. Avoidance of stockpiling by storing materials in silos and bins reduces air pollution to a great extent. When not possible, wind breaks like trees and barricades should be provided all along the open storage yards.

**2.3.4** *Size Reduction* — Size reduction operations use crushers and grinders according to size range of feeds and size reduction ratio required. Dust is discharged from crusher and grinder inlet and outlet ports. For most effective dust control, crushers and grinders should be enclosed and provided with exhaust ventilation discharging to a suitable collector. Open hoods at inlet and outlet ports are less efficient than enclosures because they need large quantities of air to produce 'capture effect' and ambient air currents may interfere with the flow of dust from source to the hood.

**2.3.5** *Classification and Mixing* — After the size reduction operation, raw materials are generally size classified and/or mixed to obtain a desired size or composition. Local exhaust ventilation systems should be specifically designed to control dust emission from these operations. Unenclosed screening operation is the major source of dust emission. Screens should, therefore, be enclosed and provided with exhaust ventilation. The area of openings in the enclosures should be kept small so that inlet face velocities through enclosure opening are sufficient to prevent escape of dust.

## 3. COKE OVENS AND BY-PRODUCTS RECOVERY

**3.1 Brief Description of Operating Process** — Coke is made by heating blended coals to a temperature of 900° to 1 100°C over a period of 10 to 20 hours to drive off the volatile matter, while retaining certain physical and chemical properties. In conventional coking process used in iron and steel works, coke is produced in slot ovens alternated with heating chambers or flues such that coal and air do not come in contact with each other during combustion. The flues between the ovens are heated with hot combustion products. The major advantage of such process is recovery of

by-products from the coal, the value of which partially affects the cost of production coke.

**3.1.1** In the conventional coke plant after coal is received crushed, screened and blended in coal preparation plant, the coal is charged in coal towers and a hopper equipped vehicle operating on top of the ovens is loaded with a charge of coal. This vehicle moves to the oven to be charged and discharges the coal from these coal hoppers through 3 to 5 charging ports in the top of the oven. The charging port lids are closed, the coal is levelled by the levelling bar, and the destructive distillation process is initiated by heat conducted into the coal from the gas being burnt in the two adjacent heating chambers. At the completion of the coking cycle, doors on each end of the oven are opened and the coke is pushed from the oven by a pusher ram through the coke guide into the coke car. The car is then transferred to a quenching station. In a wet quenching operation, water is sprayed on to the hot coke to cool it for further transport to coke sorting plant. In a dry quenching operation, unreactive gases are circulated through the hot coke, the hot gases cooled, cleaned and recirculated and the cooled coke is dropped on conveyors and passed through dedusters where fine dust is removed by blowing air over it. The coke is crushed, screened, blended and sent to different consumers from the coke sorting plant. The fumes generated while forming coke are sucked by an exhauster and the gas is sent to various chemical recovery units where valuable by-products are recovered.

**3.2 Generation of Air Pollutants** — In a coking plant, there are two types of pollution sources which differ markedly in the amount and nature of pollution they cause, in methods of combating it and in their effectiveness.

**3.2.1** Indoor sources of pollution are preparation of coal and coke, crushing, screening, loading, unloading, conveying and blending. Outdoor sources of pollution are charging and discharging of oven, quenching and leaking oven doors and by-product processing.

**3.2.2** Pollutants of varying nature are generated from by-product recovery plants mainly from open tank surface, vent pipes, leaking pump seals, centrifuges, settling tanks, transportation system of volatile compounds and various other hatches of process equipment.

**3.2.3** During handling and preparation of coal and coke, particulate matter is emitted in working areas. The reasons mentioned in **2** also apply well to coal and coke handling.

**3.2.4** During actual coking operation, dust fumes and heat are liberated. The initial coking gases which are generated when the coal charge is brought into contact with hot oven chamber walls, blow out from the oven chamber openings together with coal particles.

**3.2.5** When red hot coke is pushed out by opening the oven doors on both sides of the oven chambers, it falls from coke guide into the quenching car and generates dust. Further, the gases remaining in the oven are emitted from the oven door openings, upper part of coke guide, etc, when the oven doors are open during the pushing operation.

**3.2.6** The gases generated during the coking of coal leak from the closed openings. This occurs when the seals of the charging hole lid, ascension pipe lid, oven doors, levelling hole lid, etc, are defective.

**3.3 Measures to Control Air Pollution**

**3.3.1** To control emission of particulate matter of coal and coke during coal and coke handling, the measures given in **2.3** are sufficient.

**3.3.2** For coal preparation and coke sorting plants, the measures described in **2.3** are sufficient. Wet scrubbers, bag filters and cyclones may be used.

**3.3.3** To control emission of fumes and particulate matters from coal charging, coke discharging and oven doors, no specific measures have yet been followed in India. However, as practised in some other countries the following general measures are recommended:

a) Control of emission during charging operations,

b) Control of emission during pushing operation,

c) Control of gas leakage from oven during coking, and

d) Control of emission from quenching operation.

**3.3.3.1** *Charging operation* — Aspiration systems to increase the draft on the coke oven during charging may be adopted to extract the charging fumes into the coke oven gas collecting mains. This can be accomplished by ascension pipe ejectors using compressed air, steam, high pressure ammonia liquor, etc. The effectiveness of this technique varies from facility to facility depending upon the configuration of the gas mains and their connecting legs (goose necks), the presence of other control devices and the dimension of the oven.

Charging car mounted dust collectors of self-contained type fan and scrubber may be installed, which suck the fumes and dust during charging of coal in addition to ascension pipe ejector system and discharge by a short stack. However, this may pose mounting difficulties for larger ovens because of dimension and mass. Therefore, it may be desirable to convey sucked gases to the ground and treat them there. In the latter type, only a suction hood, a combustion device for igniting the gases and the predust collector (ordinarily scrubber) may be mounted on the carrying car and the

outlet of predust collector may be discharged to a fixed duct and gas cleaning device installed on the ground. The capacity of unit collectors are in the range of 30 000 to 60 000 $m^3/h$ depending on oven height of 4 m to 6 m.

3.3.3.2 *Pushing operation* — For pushing operation, the dust and fume generated by falling stream of hot coke may be sucked by mounting a hood and a dust collector on the coke guide car. In case of larger size and mass of such mounted unit collectors, a fixed duct system as recommended for charging car may also be envisaged. The capacity of unit collectors may be in the range of 150 000 to 270 000 $m^3/h$ depending on coke oven volumes. Normally wet collectors are used in such dust collecting systems but a bag filter with predust collectors may also be envisaged. Complete coke side enclosure and gas cleaning system may also serve the purpose, but it is uneconomical due to its vast size.

It is not essential to control the emissions on the pusher side.

3.3.3.3 *Leaks* — During cokings, gases leak out of oven door seals, ascension pipe seals, levelling hole, charging hole lids, etc. It is difficult to keep these parts in a perfectly sealed condition because of thermal strain and coal tar build-up. Such leaks can be prevented only by providing good sealing devices. Water sealing device for ascension pipe lids, and automatic sealing of charging hole by water soluble mortars, etc, may be developed to improve seals. To control gas leakage from ovens, sufficient daily maintenance is required in addition to the above mentioned measures.

3.3.3.4 *Quenching* — To reduce emission from quenching operation, in wet type quenching plants, uncontrolled particulate emission can be reduced sufficiently by simple baffles of various configurations mounted in the quench tower. Water sprays may be provided for periodically cleaning the baffles. In dry type quenching plants, it is possible to reduce particulate emission by providing local suction at coke discharge conveyors and cleaning the waste gases in two stage dust catcher of cyclone and centrifugal scrubber or cloth bag filters. Air from coke deduster can be cleaned in venture scrubber or cloth bag filters.

Gases evolved in the by-product plant should be reduced by connecting vent pipes of equipment of similar products together and subsequently cleaning the exhaust gases. Emission from open reservoirs should be controlled by providing floating lids, screens, membranes, glass beads foam, emulsion, etc. Fumes from centrifuges for anthracene and its conveyors should be removed by exhaust fans and hoods. Gases liberated from pitch collectors should be exhausted by fans. Emissions from pump handling liquid chemicals should be reduced by sealing the pump and exhausting air from shaft bushes by locally covering it.

## 4. SINTERING AND PELLETIZING PLANT

**4.1 Brief Description of Operating Process** — Sintering of ore and pelletizing of ore was developed to improve the characteristics of blast furnace feed material. Sintering plant is a major source of air-pollution and its dust emission represents an important share of the total emission from an iron and steel plant. Pelletizing is normally done in conjunction with a mining operation rather than at a steel making complex.

**4.1.1** *Sintering* — In recent years, sintering of iron ore by continuous sintering strands has developed considerably and is used widely in iron and steel plants. A continuous sinter installation includes the following:

a) A series of raw material bins like ore fines bins, blast furnace flue dust bins, return fines bins, fuel bins and bins for various additives, with feeder scales, conveyor belts, mixing drum and humidifier for the correct preparation of the sinter mix;

b) A unit for coke crushing to a grain size of about 3 mm;

c) The sinter strand, with draught fan underneath;

d) A screening unit at the discharge end of the strand to separate the return fines;

e) A sinter cooler fitted with a draught fan so that the product can be carried by conveyor belt; and

f) In some cases, a screening station before despatch of the sinter to the blast furnace.

**4.1.1.1** The iron ore fines, other iron bearing materials, coke breeze and other additives are mixed and fed on to the permeable travelling grate or strand. The upper surface of the bed of materials is fired in an ignition zone and air is drawn through the bed into a series of distribution channels called windboxes. After the mixture is ignited, the combustion zone moves downward through the bed as the grate travels, progressively igniting, drying, heating and fusing the mixture into sinter. At the end of the grate, the sinter is tipped into a crusher and is screened, cooled and screened again for subsequent transport to the blast furnace. All screened fines are returned to the sintering process. Because sinter degrades and weathers relatively easily, stockpiles are small and plants are most often located very near the blast furnace.

**4.1.2** *Pelletizing* — Pelletizing is the latest of the agglomeration processes for fines and iron ore concentrates applied on an industrial scale. Fines and concentrates which, owing to their fine grade cannot be processed in the normal sintering plants are pelletized. Pelletization can be done in

shaft furnace plants, sinter machine plants and the grate-kiln plants. The green balls are made of iron ore concentrates of very fine grade and rolled in ball drums. Materials like, bentonite, iron sulphide, calcium chloride and sodium chloride are used as binders.

**4.2 Generation of Air Pollutants**

**4.2.1** *Sintering* — Broadly, there are three types of pollution as follows:

a) The primary outdoor pollution caused by handling, storage, blending and screening and consisting mainly of fine particles;

b) Indoor pollution, which is mainly dust but also the release of sulphur dioxide from sulphur of fuel and other materials on the sintering bed; and

c) Secondary outdoor pollution by fumes since most of the dust is caught but sulphur dioxide is very difficult to eliminate.

**4.2.1.1** Dust emission originates from ore and fuel distribution points, the full crusher, the point at which the sinter mix is deposited on the strand, the neighbourhood of the sinter grate, beneath the grate, the hot sinter screening unit, the sinter cooler and the sinter crushing and screening unit. The most important source of dust are the points beneath the grate and sinter cooler. The principal toxic components of sintering gases are carbon monoxide and sulphur dioxide.

**4.2.2** *Pelletizing* — Gases and dust are formed in the calcining plant when the products of combustion of gas or fuel oil are sucked through the layer of pellets. Dust, sulphur dioxide and carbon monoxide are carried with the flue gases. Some amount of oxides of nitrogen is also formed. A large amount of dust is generated when sizing the pellets on screens and when loading them for further transport.

**4.3 Measures to Control Air Pollution** — Particulate matter is the predominant contaminant in the waste gases coming from the windbox below sintering bed. The dust is generally relatively coarse. Therefore, most sintering plants are equipped with a series of gravity separators or drop-out chambers, followed by mechanical collectors such as cyclones, to remove the coarse, abrasive dust to protect the induced draft fan from severe wear. Electrostatic precipitators may be used to remove the residual dust concentration from waste gases coming out of mechanical collectors. Fabric filters may also be used but with oily feed materials, the choice will be limited. Wet scrubbers may be used with substantial advantage in that gaseous sulphur oxides, fluorides or chlorides can be removed.

**4.3.1** Dust is generated if crushers or breakers at the discharge end of the machine are used. It may be hooded and exhausted to atmosphere.

Mechanical collectors, fabric filters and low energy venture scrubbers may be used successfully.

**4.3.2** From all the non-process sources of material handling and storage, huge dust may be emitted. Local exhaust hood over dusty operations may be used. Mechanical collectors, wet scrubbers and fabric filters should be used to clean the exhausted air. Disposal of collected dust from mechanical collector may be done by hydraulic flushing. Water spray and chemical dust suppression may also be used with the local exhaust ventilation.

## 5. BLAST FURNACE

**5.1 Brief Description of Operating Process** — Pig iron is produced in blast furnaces which are large refractory-lined structures. Materials like iron ore, sinter, pellets, limestone and coke are charged at top of the furnace by the charging skip or conveyor through a series of self-closing cone type seals. Preheated blast air is introduced through a bank of tuyeres near the bottom of the furnace and rises through the charge, reacting with the coke to form a reducing gas which reduces the oxides in the ore to metallic iron. Steam, oil, gas, pulverised coal and lime may be injected into the blast furnace to improve operation. As the burden moves downward, the molten iron collects in the hearth and is periodically tapped from the furnace into hot metal ladles. The limestone forms slag which is also tapped from the furnace into slag ladles. The slag may be granulated in slag granulation plant.

**5.2 Generation of Air Pollutants**

**5.2.1** Dust is formed during handling of materials in the high line bunkers and at charging the material into the skip chute. Dust and fumes are generated from the top of blast furnace during charging the material into blast furnace interbell space during opening of top and bottom bells.

**5.2.2** Graphite dust and fumes are generated in the cast house during the tapping, from tap holes, skimmers, hot metal troughs, slag troughs, etc.

**5.2.3** Graphite dust and carbon monoxide is generated in the pig casting machine area.

**5.2.4** Sulphur containing gaseous pollutants are generated during hydrolysis of slags in slag granulation plant. The main pollutants are hydrogen sulphide, sulphur dioxide and sulphuric acid. Part of sulphur dioxide may also be formed when sulphur dioxide comes in contact with hot molten metal surface.

**5.3 Measures to Control Air Pollution** — The following measures should be taken to control pollution:

a) Control of emissions of dust during raw material handling and preparation in high line bunkers,

b) Control of emissions of dust and gases during charging of blast furnace, and

c) Control of emission of dust and gases during tapping of molten metal and slag in cast house.

5.3.1 *High Line Bunkers* — The dust generated from various processes in high line bunker can be reduced by using covered cars, covered bunkers, covered conveyors and screens and by covering material transfer points. Local exhaust ventilation hoods should be provided at each bunker, screen conveyor loading points, skip loading points and all other dust emitting points as per the material flow details. The exhausted air should be led to a large central exhaust station and the dust collected in dry type two stage collection sytems comprising inertial collectors and battery cyclones/bag filters.

5.3.2 *Charging of Blast Furnace* — Normally no exhaust ventilation is envisaged from the top of blast furnace where huge amount of dust and gases come out during opening of large and small bell. In case of conveyor charging of materials for large blast furnaces, covered conveyors with local exhaust ventilation should be used which may be connected to blast furnace gas cleaning plant. The reduction in emission may further be done by certain technological improvements as follows:

a) Use of tough sinter and coke, and

b) Creating pressure in the inter bell space slightly in excess of that at the charge hole by injecting cleaned blast furnace gas in the space.

5.3.3 *Cast House* — Fumes and graphite flakes emitted from the surface of the molten metal when it runs through open runners pollute the cast house area and the adjoining areas by leaking gases and dust from various openings of cast house. Normally, no measure is provided to suck the emitted pollutants, but its effect may be reduced by the following methods:

a) Exhausting large volume of air from the space above casting operation and cleaning it in bag filters or electrostatic precipitators,

b) Suppression of fumes by covering the runner system and hooding the tap spout and cleaning the gases in bag filters or electrostatic precipitator, and

c) A combination of (a) and (b) to optimise fume collection by sucking fumes from large free hanging hood during the initial and later

stages of tapping ( secondary collection system ) and from local exhaust ventilation during tapping from runner system ( primary collection system ) and combining the both to an integrated system. The system is optimum as large quantity of instantaneous fumes are generated during initial and later stage of tapping and a lower steady rate of fume generation persists during ordinary tapping. The gases are cleaned in bag filter or electrostatic precipitator.

**5.3.3.1** In addition to local exhaust ventilation and general exhaust ventilation, sufficient provision for general air exchange should be provided by designing an effective natural ventilation system in cast house.

**5.3.4** *Pig Casting Machine* — A portion of cast iron produced in blast furnace is cast directly in small size moulds in pig casting machine to make it saleable. Emission of graphite flakes from cooling surfaces of molten metal and carbon monoxide pollute the working zone environment. The working zone concentration of dust and carbon monoxide being low, no specific local exhaust ventilation is recommended at present.

**5.3.5** *Slag Granulation* — The gaseous pollutants generated in slag granulation plant are vented out to atmosphere by hooding the source and connecting it to a tall stack to create natural draft. Except for changes in slag practice, no successful control effort has so far been achieved to reduce emission.

## 6. EXTERNAL DESULPHURISATION AND DESILICONISATION OF HOT METAL

**6.1 Brief Description of Operation Process** — Before hot metal is sent to steel melting shop, its sulphur content is controlled within predetermined limits to improve the quality of steel. This is achieved in an external desulphurisation plant where desulphurising agents like calcium carbide, soda ash-lime mixture and magnesium compounds are injected into the hot metal in the ladle itself. The sulphur is removed by desulphurising agents in the form of slag. In case soda ash-lime mixture is used, the hot metal undergoes desiliconisation prior to desulphurising. Hot metal temperature is raised by mixing limestone and iron ore in it and blowing oxygen into it.

**6.2 Generation of Air Pollutants** — Huge amount of dust is generated during desiliconising operation. During desulphurising operation however, not much of dust is generated. As the operations are done in the hot metal ladle itself, the point of dust generation is ladle top. Other dust generating sources are handling, crushing and screening of desulphurising and desiliconising agents. No desiliconising operation is needed when calcium carbide is used as desulphurising agent and hence less dust is generated.

**6.3 Measures to Control Air Pollution** — The dust generated during desulphurising and desiliconising operation should be cleaned in bag houses with

or without a cyclone. From other material processing sources, dusty air drawn by dust extraction system should be cleaned in high efficiency cyclones or bag filters. Wet collection, when calcium carbide is used, is prohibited.

**6.3.1** The high temperature dusty air sucked from ladles during desulphurising and desiliconising operation should be collected by a network of movable hoods and duct lines and the air cleaned in cloth bag filters which are able to stand high temperature. In case of use of calcium carbide as desulphurising agent, spark arrestors or suitable devices should be provided to prevent chances of explosion. The air sucked in hoods should be cooled by mixing outside air or in a suitable waste heat recovery system. A cyclone before bag filter is envisaged in case of heavy dust load.

**6.3.2** The non-process dust generated during processing and handling of desulphurising and desiliconising agents should be collected by local exhaust hoods and cleaned in dry cyclones/bag filters.

## 7. MIXER

**7.1 Brief Description of Operating Process** — Molten iron arrives from the blast furnace in hot metal cars and is transferred to refractory lined vessels known as mixers for intermediate storage before transfer to steel melting shop. On demand from steel melting shop,the molten iron is transferred to ladle for charging into the furnaces by slowly tilting the mixer vessel.

**7.2 Generation of Air Pollutants** — The transfer of hot metal evolves graphite of 'kish' from the cooling carbon saturated molten metal, and iron oxide as some of the metal is oxidized on contact with air. Particulate matter contains coarse 'kish' and finer iron oxides.

### 7.3 Measures to Control Air Pollution

**7.3.1** The entire vessel top should be covered with a large suction hood of movable type and connected to exhaust ventilation system.

**7.3.2** Early control efforts consisted of the installation of multiple-tube cyclones which removed most of the 'kish' particles but passed the finer more visible iron oxide particles. Fabric filters are now widely used to reduce total particulate discharge from hot metal transfer operation.

**7.3.3** The hood collecting the fumes from hot metal mixers is largely restricted by the plant layout. Various types of hoods are conceivable, since the optimum shape of the hood would vary with its location. In designing an effective hood for collecting all fumes efficiently, including those emitted from the tap hole before and after the discharge of hot

metal from the mixer, the following aspects should be considered:

a) Since the distance between the mixer and the hood face is great, natural drafts due to flow of hot air occurs, when hot metal is discharged. To prevent the inflow of external air into the hood due to the draft, the space between the mixer and the hood should be reduced to the minimum;

b) The openings from where fumes may leak out should be sealed by shutters; and

c) Separate hood over tapping port and mixer top may be envisaged.

## 8. OPEN HEARTH FURNACES

**8.1 Brief Description of Operating Process** — The open hearth furnace consists of a brick lined arch roofed vessel with regeneration type of heating device. Molten iron, scrap, solid pig iron, limestone and ore is charged and melted for 6 to 12 hours. Carbon in the iron reacts with oxygen in the ore creating an ore boil. This is followed by lime boil in which limestone is calcined and slag is formed. The batch of molten metal in the furnace which is called a heat, is then refined to obtain desired metallurgical characteristics. Oxygen may be injected to hasten melting or to aid in refining. Following refining the heat is tapped into a steel ladle through a tap hole in the back wall of the furnace. Alloying elements may be added to the ladle during tapping. Ingot moulds are filled with molten steel from the ladle.

**8.2 Generation of Air Pollutants**

**8.2.1** The main atmospheric pollutants from the open hearth process are as given below:

a) Grit and dust from the charged materials;

b) Iron oxide fumes, particularly when gaseous oxygen is used for refining;

c) Sulphur oxides, mainly from the fuel; and

d) Nitrogen oxides, the amount of which rises with rise in temperature and with an excess of oxygen in the combustion products.

**8.2.2** Emissions of particulate matters in varying quantities and of different compositions are observed during the following operations:

a) During charging, minute particles of iron ore, limestone and other components are carried away by the flow of gases;

b) During the period of tapping off the iron, large amount of dust in the escaping flue gases is observed;

c) During the melting period, when oxygen is blown into the bath, maximum amount of dust is evolved approximately in the middle of the period; and

d) During the refining period the dust content of the flue gases is considerably lower than during the melting period.

**8.2.3** The concentration of oxides of sulphur in the escaping combustion products is directly proportional to the capacity of the furnace and sulphur content of the charge and inversely proportional to the duration of melting and refining periods and the amount of escaping combustion product.

**8.2.4** The formation of oxides of nitrogen depends on the temperature and excess of oxygen in the products of combustion. It attains a constant value quickly.

**8.3 Measures to Control Air Pollution**

**8.3.1** The control of open hearth emissions can be accomplished with electrostatic precipitators and venturi scrubbers. On furnaces with waste heat boilers, precipitators are a better choice because the gases are ideally suitable for precipitator application. For furnaces without waste heat boilers, venturi scrubbers may offer an economic advantage since the additional cost of installing waste heat boilers to cool the gases to accommodate precipitator can be large. In one of the open hearth furnaces abroad, the gases are cooled in a waste heat boiler or the waste heat boiler can be by-passed and the gases cooled in an evaporation chamber. The evaporation chamber has a resistance of 500 to 600 kPa. The gas temperature reduced from 600 to 250°C and the gases are then cleaned in venturi scrubbers having resistance of 7 to 8 kPa. A residual dust concentration of 80 mg/$m^3$ normal is obtained even with initial concentration of 16 g/$m^3$ normal.

**8.3.2** At present, the oxides of sulphur and nitrogen are left to the atmosphere by tall chimneys.

**8.3.3** In case of furnaces not using oxygen for refining, dust emission is expected to be quite low and depending upon the merit of the case, a gas cleaning plant may or may not be required. However, height of chimney should be adequate for dispersal of emitted pollutants.

**8.3.4** All the non-process emissions of particulate from dry material handling and storage systems should be reduced by providing local exhaust ventilation and cleaning the exhausted air in dry cyclones or bag filters.

## 9. CONVERTER

**9.1 General Description of Operating Process** — LD converter is one of the most accepted and used method of basic oxygen steel making in India. Most basic oxygen furnaces consist of large refractory-lined, pear shaped vessels mounted in a trunnion to permit full rotation for various operations. The vessel is tilted and charged with scrap and molten iron. Calcined lime is added as flux through flux charging chute. A water cooled oxygen lance is lowered through the top of the upright vessel and high purity oxygen is blown into the molten metal bath. Violent agitation and intimate mixing of the bath materials causes rapid oxidation of carbon and other impurities, as well as of some iron. The reaction is exothermic and requires no fuel. Slag is formed on the surface of the bath. When the entire charge is melted and the metallurgical requirements are met, the vessel is tilted to tap the molten steel through a tap hole in the vessel into a steel ladle for subsequent teeming or continuous casting. Slag is removed by tilting the furnace in the opposite direction so that it pours into the slag pot. An entire heat cycle may require only 30 to 50 minutes.

**9.2 Generation of Air Pollutants** — Generation of air pollutants takes place from the following operations:

a) Charging of hot metal scrap and flux into converter,
b) Steel making in the converter (blowing),
c) Tapping from converter,
d) Skull cutting from converter top,
e) Transportation of flux and alloys,
f) Skull cutting from ladle, and
g) Skull cutting from oxygen lance.

**9.2.1** *Charging* — When scrap and molten iron are charged to the vessel, pollutants are evolved. The pollutants consist of 'kish' and iron oxide from hot metal, and dirt, carbon monoxide and volatile materials which may be borne or driven from the scrap. The quality of scrap is the single most important face affecting the magnitude of charging emission.

**9.2.2** *Steel Making* — Converter gases are formed during steel making as a result of burning out of the carbon contained in the charge and decomposition of the limestone. The converter gases formed change with the consumption of oxygen. The converter gases contain highly dispersed dust and toxic gases like carbon monoxide, sulphur dioxide and oxides of nitrogen. Despite large number of investigations that have been carried out, the nature of the generation of highly dispersed converter dust (brown iron oxide fumes) is not yet sufficiently clear.

9.2.2.1 On the interface of the molten metal and gas, oxygen is dissolved in the metal and oxidises the carbon contained in it forming carbon monoxide.

9.2.2.2 Sulphur dioxide formed depends on the sulphur content of pig iron, lime, ore and other admixture.

9.2.2.3 Normally, oxides of nitrogen are not formed in the converter gas at the vessel outlet but are formed subsequently when the gases are burnt in boilers.

9.2.3 *Tapping* — Tapping emissions are generally similar to charging emissions but are less intensive.

9.2.4 *Flux and Alloy Handling* — Emission of particulate matters take place at material handling system of flux and alloys.

9.2.5 *Skull Cutting at Converter Top Ladle and Lance* — Emission of particulate matter takes place during skull cutting operations.

**9.3 Measures to Control Air Pollution** — Fumes and converter gas generated during charging, steel making, tapping and converter top skull cutting should be exhausted into a gas cleaning plant through waste heat boilers. Secondary hoods fitted over the converter at roof trusses may be provided to suck escaping fumes which may be cleaned in the same gas cleaning plant.

The dust generated during flux and alloy transportation should be collected by local exhaust ventilation systems. The dust generated skull cutting of lance and ladle should be exhausted through local dust extraction systems.

9.3.1 *Blowing Operation* — To capture fumes generated during blowing, a hood should be placed above the furnace. The waste gases at temperature ranging from 1 400 to 2 000°C should first be cooled to about 200°C before being passed to dust collectors. The gases should be cooled on leaving the converter by heat radiation, convection or by water evaporation. The radiation heat may be trapped by passing the gases through a low pressure boiler located in the hood above the converter and recovering the steam. The performance of such boilers is poor and hence high pressure boilers, with additional oil burners, which can work during intermediate stoppage of furnace to ensure continuous steam generation may be envisaged. Another means of recovering radiation heat of waste gases is to use water cooled hoods, with or without water evaporation. Gases may also be cooled by water spray but the dust collecting stage which follows should be able to clean gases with large water vapour content. Instead of burning the carbon monoxide in the normal way of excess of air at the furnace

outlet, the gases may be trapped without combustion for subsequent use within the plant, after sufficient cleaning, as a fuel.

For cleaning the waste gas, venturi scrubbers, electrostatic precipitators or fabric filters should be used depending upon technique of gas cooling in addition to other technological considerations.

**9.3.2** *Charging and Tapping Operation* — The fumes resulting from the charging and converter top skull cutting may be sucked by auxiliary fume collecting hood above the charging side. This hood should normally be installed below the crane girder although it would face heavy space limitation. Design considerations to ensure efficient suction should be as follows:

a) The critical distance from the hood to which crane, ladle, scrap chute, etc. can approach when charging scrap and hot metal into the vessel should be carefully established. Then the hood should be located where the buoyancy of generated fumes can be effectively utilized;

b) The converter should be perfectly enclosed except at charging side so that there is no leakage of fumes;

c) Provision of a laterally movable dust shielding gate on the charging side as it is effective for handling the fumes resulting from refining, tapping and furnace top skull cutting with a minimum of gas suction; and

d) The hood should be lined for high temperature resistance.

**9.3.2.1** In case of lack of space to install auxiliary hoods, canopy hoods may also be installed in the roof trusses of the building to extract fumes that local hoods do not capture. The auxiliary hoods may be connected to dust collector. Fabric filters and wet scrubbers are recommended.

**9.3.3** *Skull Cutting and Material Transfer Points* — All other non-process areas where dust is generated should be connected to a centralized exhaust ventilation system with a bag filter. The fumes from charging and tapping operations may also be connected to this system. Independent system for the group of localized dust generating sources is recommended with bag filter as dust catcher.

## 10. ELECTRIC FURNACE STEEL MAKING

**10.1 Brief Description of Operating Process** — Electric arc furnace steel making is a batch process with heats generally ranging in duration from 1½ to 5 hours for carbon steel production and 5 to 10 hours for alloy steel production. The cyclic operation consists of one or more charges of

scrap steel from the scrap charging bucket, followed by melting, refining and tapping through the tap spout into the steel ladle. The furnace is a cylindrical, refractory lined shell into which the steel scrap/sponge iron is dropped. An electric arc is imparted to the charge through a carbon electrode system and may or may not be injected for refining purposes. The furnace is tilted for tapping or removal of slag.

**10.2 Generation of Air Pollutants** — During the melting period, pollutants generated are dust and carbon monoxide. Sometimes oxides of nitrogen and sulphur dioxide are also formed. Less amount of pollutants are generated during tapping and charging. Compounds of manganese and chromium are found in waste gases. Quantity of carbon monoxide may be more than 30 percent of the total amount of gases but it may be burnt before discharge.

**10.2.1** Generation of dust depends upon such variables as charging method quality of scrap, oxygen blowing rate, furnace operating practice and the type of steel produced.

**10.2.2** Generation of carbon monoxide occurs during reaction of the carbon in the electrodes or steel with the directly applied oxygen, or form air induced into the furnaces.

**10.2.3** Sometimes sulphur dioxide and oxides of nitrogen can be formed and occasionally cynides and hydrofluoric acid are also formed.

**10.3 Measures to Control Air Pollution** — The control of emission from electric arc furnace may be done in the following three ways or combinations of these:

a) Direct shell evacuation,

b) Roof mounted hoods, and

c) Canopy hoods.

**10.3.1** Direct shell evacuation may be done by a fourth hole in the furnace roof by exhausting the gases formed. The hood mounted on roof may be water cooled and should be suitable for furnace tilting operation. The gases may further be cooled by evaporative cooling, addition of dilution air or radient convective gas cooling. Air should be induced for complete combustion of carbon monoxide. This procedure is suitable for large furnaces.

**10.3.2** Roof mounted hoods are hoods located just above the roof which suck off the escaping fumes. Sufficient dilution takes place by mixing of shop air with the fumes. However, water cooled hoods may be envisaged.

**10.3.3** Canopy hoods are located well above the furnace in the roof trusses or in places of monitor roof. Cooling of the gas is achieved by sufficient dilution with shop air. These should be used in addition to direct shell evacuation to take care of any uncaptured fumes.

**10.3.4** The gases captured by combination of fourth hole exhaust and canopy hoods may be cleaned in bag filters. However, venturi scrubbers and electrostatic precipitator can also be used, depending on cost. Cooling may not be needed for such combinations.

**10.3.5** Charging and tapping emissions represent only 2 to 5 percent by mass of total emission and occur for short period of time. Canopy hoods normally take care of these emissions.

## 11. DIRECT REDUCTION PROCESS

**11.1 Brief Description of Operation Process** — The iron ores can be converted to metallic iron without melting by direct reduction. The metallic iron is also called sponge iron which is a comparatively purer form of iron. The reduction takes place when the iron ore pellets and non-coking coal are reduced in chambers. It can also be reduced by natural gas or liquid hydrocarbons. The available process types are:

a) fluid beds,

b) vertical shaft moving beds,

c) vertical shaft fixed beds, and

d) rotary kiln.

**11.2 Generation of Pollutants** — Small quantities of air pollutants are generated in the process mainly because of the closely controlled recirculated reducing gas systems. Dust is generated only from material transportation processes.

**11.3 Measures to Control Air Pollution** — No scientifically proven and well documented pollution control system is so far known for the main process. However, for material transportation processing and storage processes, conventional local dust extraction systems may be used. Fabric filters should be used to clean the air.

## 12. CONTINUOUS CASTING PROCESS

**12.1 Brief Description of Operating Process** — Molten steel from steel melting furnaces is converted to slabs or blooms by allowing it to flow in

a well guided shape. It gets cooled during the flow itself. Moulding, stripping, soaking, blooming and slabbing of steel are avoided in this process, and hence it is more economical than conventional bloom and slab producing techniques.

**12.1.1** Ladles with molten steel (heat) are brought from steel melting shop and placed on a lift and turn stand, allowed to be tapped and stored in tundish. Molten steel is regulated to flow into a copper mould with false bottom. When an adequately solidified skin has formed on the periphery of the molten steel out of itself in the mould, the false bottom is pulled down to allow the metal to move along strand guide section. The strand thus formed passes through the secondary cooling zone where intensive spray of water is done to solidify most of the molten metal with the strand. The skin of the strand is prevented from getting bulged due to high ferrostatic pressure acting within it by pinch roll units, being hydraulically pressed against the strand. The strand, after getting fully solidified during its predetermined length or run, is cut by torch cutting machines. The tundish keeps on filling molten steel and the casting and cutting operation continues. Vertical or horizontal type continuous casting machines are used for casting mild steel, stainless steel, alloy steel or other high alloy steels.

**12.2 Generation of Air Pollutants** — Main point of generation of pollutants is the cutting section where huge amount of products of oxyacetylene gas, dust and vapours are produced. In secondary cooling zone steam and vapour are generated. During feeding of casting powder in the mould, fumes of burnt casting powder are generated. During tundish heating, drying and cooling, products of combustion of coke oven gas are generated. In mortars preparation plant fine dust is generated. If the tundishes are kept in nitrogen filled chambers for improving quality of steel, oxides of nitrogen are generated.

**12.3 Measures to Control Air Pollution** — The gaseous fumes and vapours from torch cutting machine should be exhausted by providing specially designed exhaust hoods over the affected area. The steam generated in the secondary cooling zone should also be exhausted by covering the entire cooling zone and providing exhaust ventilation hoods. The exhaust from torch cutting machine should be mixed with steam from secondary cooling zone and the collected fume exhausted to atmosphere by a central exhaust station having exhaust fans of suitable capacity. The dust from mortar preparation should be exhausted and cleaned in bag filters.

The oxides of nitrogen generated over tundish, if it is kept in nitrogen atmosphere, should be exhausted, by specially designed water cooled hoods, to atmosphere at sufficient height.

## 13. ROLLING MILLS AND FINISHING MILLS

**13.1 Brief Description of Operating Process** — After steel is tapped in molten form from open hearth, LD converter or electric arc furnace, it is poured into ingots, if the metal is not diverted to continuous casting plant. The ingots are heated, to a temperature suitable for hot rolling, in soaking pits. After being rolled into slab or bloom in slabbing or blooming mill, the slabs/blooms are again heated in re-heating furnaces before further size reduction by rolling takes place. These furnaces (soaking pits and re-heating furnaces) are fired with mixture of coke oven gas and blast furnace gas and/or oil or natural gas.

**13.1.1** Slabs and blooms require surface preparation to remove defects. This is done in scarfing machines by removing a thin layer of steel surface by directing an oxyacetylene gas flame.

**13.1.2** Reduction of the gauge of steel strip is accomplished in hot rolling mills. A cold rolling mill is used for further gauge reduction. Before cold rolling, pickling of the steel is required to remove scale and oxides on the surface of the strip. Pickling is accomplished by passing steel through a bath of sulphuric, hydrochloric or nitric-hydrofluoric acid.

**13.1.3** Numerous other metallurgical and chemical coating processes for finishing steel may be conducted. These may include normalizing, annealing, heat treating, galvanizing, tinning or painting. Various gauge reduction, shape formation and quality improvements may be done in double cold reduction mills, 2-stand and 5-stand tandem mill, slitting, shearing, corrugating, electrolytic cleaning lines, skin pass mills, polishing lines, etc.

**13.2 Generation of Air Pollutants** — Sources of air-pollution in rolling mills are as follows:

a) Re-heat furnaces,

b) Scarfing,

c) Pickling,

d) High speed rolling,

e) Galvanizing, and

f) Polishing operations.

**13.2.1** Emission from reheat furnaces are limited to products of combustion. Oxides of nitrogen and sulphur may be produced from burning of fuel. During scarfing, iron oxides fumes may be generated. While pickling, acid mists are evolved from hot acid baths. Oxides of nitrogen may be formed while using nitric-hydrofluoric acid. During high speed rolling,

fog, and oil mist may be generated when the roll coolants come in contact with high temperature and pressure between rolls. In the process of galvanizing, emission of ammonium chloride, zinc oxides, zinc, ammonia and oil may occur. During polishing, large amount of particulates are generated.

**13.3 Measures to Control Air Pollution**

**13.3.1** *Re-heat Furnace* — Exhaust of products of combustion from the various furnaces should be done either by natural drought or forced draught. No cleaning device is suggested but the gases, depending on the concentration of pollutants, should be released by tall chimneys.

**13.3.2** *Scarfing* — Local exhaust ventilation hoods should be placed over scarfing machines and the exhausted gases cleaned in wet scrubbers or wet electrostatic precipitators. Use of dry precipitators may create problems of severe corrosion.

**13.3.3** *Pickling* — The acid tanks should be hooded and exhaust ventilation with or without supply of air to guide the fumes to enter exhaust slots should be provided. Packed towers and wet scrubbers should be used to clean the air of acid mists.

**13.3.4** *Rolling* — The rolling areas should be hooded and the fog exhausted by exhaust ventilation system. Wet scrubbers or oil wetted filters should be used to clean the air of fog. Setting chambers with baffle plates and stack skimmers may also be used.

**13.3.5** *Galvanizing* — Local exhaust ventilation should be provided by providing local hoods (where space permits a canopy hood) over zinc bath. Electrostatic precipitators, wet scrubbers and fabric filters may be used to clean the air. However, while using fabric filters, the gas should be heated and its moisture removed by injecting dry additives.

**13.3.6** *Polishing* — Local exhaust hood should be provided over polishing operation and the air cleaned in wet dynamic scrubbers.

## 14. REFRACTORIES MATERIAL PLANT

**14.1 Brief Description of Operating Process** — In all integrated iron and steel plants, refractories of various shapes, sizes and kinds are used for lining various furnaces. In addition to these refractories materials like calcined lime and dolomite are needed in different processes. Special tar-dolomite bricks are needed for lining LD converters. A typical refractories materials plant in an integrated iron and steel plant provides tar-dolomite bricks, calcined lime and dolomite to the plant. Requirements

of other refractories are normally met by refractories plant which may or may not form a part of an iron and steel plant.

**14.1.1** Dolomite is calcined in rotary kilns, shaft or cupola furnaces. Rotary kilns are fired with coke-oven gas, fuel oil and coal dust. Limestone is calcined in rotary kilns or shaft furnaces. Usually fuel oil is used as a fuel for calcining limestone. Before calcining, the limestone and dolomite undergo size reduction and classification processes. The calcined lime and dolomite are sent to user departments after cooling and screening. Calcined dolomite is mixed with tar and cold pressed to form tar-dolomite bricks. The bricks may or may not be baked. However, dolomite bricks, because of hygroscopic nature, are stored in air-conditioned stores.

**14.2 Generation of Air Pollutants** — In the process of calcining raw materials for the production of refractories, a large amount of solid and gaseous substances are exhausted into the atmosphere with the process and non-process waste gases. The highest amount of dust is ejected when calcining the raw materials. A large amount of carbon dioxide is liberated on calcining raw dolomite. Traces of oxides of nitrogen may also be formed. Carbon dioxide and nitrogen oxides are also formed while calcining limestone. Nuisance dust is generated in handling, crushing, screening and storing of raw materials.

**14.3 Measures to Control Air Pollution** — In order to catch dust, kiln emissions should be controlled by fabric collectors, water scrubbers and electrostatic precipitators. The choice of the type of collector depends as under:

a) Presence of tar in case of coal-fired kilns may make fabric collector unsuitable; and

b) The use of scrubber water in process associated with lime production operation. (Such as the entire amount being utilized in water softening plant reducing the demand of raw water in softening plant).

**14.3.1** Fabric filters are often considered more desirable because visible plumes are eliminated but wet scrubbers are recommended as they will reduce cost of water treatment operation.

**14.3.2** For non-process dust emission from screens, bunkers, charging end of kiln, discharge end of kiln and conveyor transfer points, local exhaust ventilation with wet scrubbers, fabric filters and cyclones should be provided. Dust collected from discharge end of kiln, however, may not be connected to a dust collection device but the air may be thrown into the kiln itself which will move along with the heated gases to the main gas cleaning plant.

## 15. THERMAL POWER PLANT

**15.1 Brief Description of Operating Process** — In integrated iron and steel plants, captive power plants have occupied the place of an indespensable unit to meet the huge electric power requirements. The captive power plants are mainly based on fossil fuels. Fuel burning systems are utilized to generate steam for power generation. The primary function of the fuel burning system in process of steam generation is to provide controlled efficient conversion of the chemical energy of the fuel into heat energy which is then transferred to the heat absorbing surfaces of steam generator. Fuel burning systems function to do this by introducing the fuel and air for combustion, mixing these reactants, igniting the mixture and distributing the flame envelope and the products of combustion. The steam so produced is directed to steam turbines for generation of power and the products of combustion are sent to gas cleaning plants before discharging to atmosphere. The fuel used for captive power plants is non-coking coal.

**15.2 Generation of Air Pollutants** — The main source of air pollution is the products of combustion which contains substantial amount of dust (fly ash), and some amount of sulphur dioxide and oxides of nitrogen. The amount of dust evolved is mainly determined by the ash content in the coal and the combustion process. The amount of sulphur dioxide depends on the amount of combustible sulphur in the coal. The quantity of oxides of nitrogen evolved is related to the content of free oxygen in the boiler and the temperature in it. Other sources of air-pollutants are the coal preparation plant and the pollutant is particulate matter.

**15.3 Measures to Control Air Pollution** — The fly ash generated in the boiler and carried away by the flue gases is collected in dust collectors. The sulphur content in Indian coal being low, no specific sulphur dioxide removal system is necessary. For oxides of nitrogen too no immediate cleaning device for oxides of nitrogen is necessary. However, provision should be kept for installing cleaning equipment for sulphur dioxide and oxides of nitrogen in future.

**15.3.1** For cleaning particulate emission, which is a critical problem for pulverized coal fired boilers using coal of high ash content and low sulphur content, settling chambers, electrostatic precipitators and fabric filters may be used. Electrostatic precipitators installed on hot side of the air-preheater are recommended for removal of particulate matter from boilers using low sulphur coal. Electrostatic precipitators may be used in combination with low efficiency cyclone collectors which precede the electrostatic precipitators. Cyclone collectors, following high-efficiency electrostatic precipitators help to sustain the highest possible efficiency by cleaning up puffs due to rapping, soot blowing and minor slight malfunctions of the pricipitators. Cost of hot side precipitator is large as it has to handle greater volume of gas involved.

**15.3.2** For low sulphur high ash coal, wet scrubbers in series may offer some advantage where high efficiency of ash removal is required over electrostatic precipitators.

**15.3.3** For coal handling plants, where nuisance dust creates environmental problems, use of covered conveyors, wetting sprays at transfer points, sprinkling of haulways, treatment of storage piles with polymeric compounds and enclosure of live piles may be required singly or in combination with local dust extraction and cleaning system. The extracted air should be cleaned in wet scrubbers.

**15.3.4** For dispersal of dust, sulphur dioxide and oxides of nitrogen the stack of gas cleaning plant should have sufficient height to control ground level concentration of each pollutant within acceptable limits.

## 16. IRON AND STEEL FOUNDRY

**16.1 Brief Description of Operating Process** — Iron and steel foundries produce castings of grey iron malleable iron, ductile iron and steel to be used as consumables in iron and steel plants. Scrap metal is melted with proper alloys, and the molten metal is cast into sand moulds. When the casting solidifies, it is stripped from the mould. cleaned, heat treated and finished. The mould sand is reclaimed, conditioned and used for further core and mould making.

**16.1.1** Iron is generally melted in cupola, a refractory lined cylindrical vessel equipped with combustion air tuyeres at the base and a charging door or opening near the top, through which coke, limestone and scrap metal are charged. A charge of coke is made initially and ignited to heat the cupola. The cupola is then charged with coke, limestone and scrap metal to a level just below the charging door. The heat from the burning coke melts the iron. As the charge melts and descends through the shaft, additional charge materials are added and molten iron and slag are removed from tap holes. The combustion air may be heated to improve performance. Waste gases are emitted from the top of the cupola. The tapped molten iron is poured into casting moulds. Molten steel is produced in electric arc furnaces or open hearth furnaces.

**16.1.2** The cooled castings separated from the sand moulds either manually or on vibrating screen or shake-out stations. The sand is reclaimed and reconditioned by screening, mixing, control of moisture and addition of binder and is made into new moulds. Cores are specially formulated from sand and organic binders and are cured in core ovens. The castings are then cleaned of metallic burns and sticking sand is fettled by shot blasting or tumbling.

**16.2 Generation of Air Pollutants** — Major sources of air pollution in an iron and steel foundry are as given below:

a) Melting furnaces,

b) Shake-out,

c) Sand handling and conditioning system,

d) Core making, and

e) Fettling.

**16.2.1** *Cupolas* — The gases evolved in cupola furnaces contain carbon monoxide, sulphur dioxide and dust. The concentration of sulphur dioxide in the furnace gases depends on the amount of sulphur in the charge and coke. The dust emitted from a cupola consists of metallic oxides, coke, ash and volatilized materials driven from the scrap. Carbon monoxide is formed by the reaction of carbon in the coke with oxygen in blast air. When molten cast iron is tapped off from a cupola, carbon monoxide and graphite dust are emitted.

**16.2.2** *Shake-Out* — During knocking castings to remove them from moulds in shake-outs, harmful vapours, gases and dust of silica sand are evolved.

**16.2.3** *Sand Handling and Conditioning System* — In sand handling and conditioning, emission of silica sand dust is a predominant pollutant.

**16.2.4** *Core Making* — Carbon monoxide and sulphur dioxide are emitted while drying moulds and cores in ovens. The quantities of carbon monoxide and sulphur dioxide depend on amount of fuel consumed for drying moulds and cores.

**16.2.5** *Fettling* — Excessive metallic dusts are generated in fettling operation.

**16.3 Measures to Control Air Pollution**

**16.3.1** *Cupolas* — Control of cupola emissions may be done by the use of fabric filters, wet scrubbers or electrostatic precipitators. While using fabric filter, the gases should be cooled and carbon monoxide fully burned to protect bags from high temperature. After burners may be used on the top of cupola itself to burn the gas. Cooling may be done by radiant-convective or evaporative method. To minimize cooling requirements, high temperature fibre glass filters may be used.

Scrubbers have the advantage of requiring no precooling of gases, but cost of water treatment may be higher. Electrostatic precipitators are

normally not advisable because of high dust resistivity and presence of carbon monoxide.

**16.3.2** *Shake-Outs* — Various standard hood designs for covering shake-outs are available. Exhaust hoods may be used in combination with plenum air curtains. The exhausted gases should be directed to wet scrubbers, fabric filter and sometimes to mechanical collectors. Medium energy wet scrubbers are best suited. However, fabric filters are recommended to collect valuable binders and sand.

**16.3.3** *Sand Handling and Conditioning* — Sand conveyors should normally be located underground and provided with local exhaust ventilation system. The exhaust may be combined with the exhaust of shake-outs or may be treated separately in wet scrubbers, fabric filters or mechanical collectors.

**16.3.4** *Core Making* — The flue gases from core making and mould drying ovens are normally recirculated to the oven and a small portion bled out. To protect the environment from carbon monoxide pollution, provision should be made to flare up the gases at sufficient height. Alternatively, the combustible flue gases should be passed through an after-burner and heat exchanger and gases discharged to atmosphere. The heat exchanger may be used to heat the supply air to the ovens. This helps in recovering the fuel value of fumes.

**16.3.5** *Fettling* — Shot blasting is done in cubicles. The dust generated should be exhausted by hoods fitted with the cubicles. The air should be cleaned in fabric filters or wet scrubbers. If fettling is done in tumbling drums, the drum should be enclosed and the enclosure ventilated by providing local exhaust hoods and the air cleaned in fabric filters or scrubbers.

## 17. DUST AND MIST COLLECTORS

**17.1** A list of recommended dust and mist collectors is given in Table 1.

## 18. LOCATION AND LAYOUT OF IRON AND STEEL PLANTS

**18.1** While deciding location of a new iron and steel plant, the micrometeorological factor prevailing in the area and the topography of the area should be considered ( *see* IS : 8829-1978* ). Areas with frequent record of inversion occurance and valleys should not be considered as prospective location from air pollution episode view point. The location of residential areas should be such that they are located towards the cleaner side of the plant ( for example: rolling mills ). There should be a green belt of adequate width around the plant boundary to absorb noise and arrest dust.

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*Guidelines for micrometeorological techniques in air pollution studies.

## TABLE 1 LIST OF AVAILABLE DUST AND MIST COLLECTORS
(CLAUSE 17.1)

| SECTION (1) | ELECTRO-STATIC PRECIPITATOR (2) | FABRIC FILTER (3) | MEDIUM DIA CYCLONE (4) | BATTERY CYCLONE (SMALL DIA) (5) | WET SCRUBBER (6) | SETTLING CHAMBERS (7) | MIST ELIMINATORS (8) | VENTURI SCRUBBER (9) |
|---|---|---|---|---|---|---|---|---|
| RAW MATERIAL HANDLING | | X | X | X | X | X | | |
| COKE OVENS AND BY-PRODUCTS RECOVERY | X | X | X | | X | | | X |
| SINTERING AND PELLETISING PLANTS | X | X | | X | X | X | | X |
| BLAST FURNACE | X | X | | X | X | X | | X |
| EXTERNAL DESULPHURISATION AND DESILICONISATION OF HOT METAL | | X | X | | | | | |
| MIXER | | X | | X | | | | |
| OPEN HEARTH FURNACE | X | X | X | | X | | | X |
| LD CONVERTER | X | X | X | | X | | | X |
| ELECTRIC ARC FURNACE | X | X | | | | | | X |
| DIRECT REDUCTION FURNACE | | X | | | X | | | |
| CONTINUOUS CASTING | X | X | X | | | | | |
| ROLLING MILLS AND FINISHING MILLS | X | X | | | X | | X | |
| REFRACTORIES MATERIAL PLANT | X | X | X | X | X | | | |
| THERMAL POWER PLANT | X | X | X | X | X | | | |
| IRON AND STEEL PLANT | X | X | | | X | | | |

**18.2** The layout of the plant should be such that a predominant wind direction is from cleaner side of plant ( that is, rolling mills ) to pollution emitting side of plant. The layout of highly polluting shops should be preferably perpendicular to the predominant wind direction.

## 19. STACKS

**19.1** The emission rate of pollutants and height of stacks are the most important factors contributing to air pollution. Emission of pollutants from stacks should not be allowed to exceed the limits prescribed in IS : 11247-1985*. Height of the stacks should be decided to limit the ground level concentration of each pollutant, whether treated or not, to maximum permissible limits. To the extent possible, centralized stacks should be used.

## 20. AIR POLLUTION SURVEY

**20.1** An air-pollution survey of the localities around the proposed plant or proposed expansion should be conducted to determine the background pollution level already existing, due to natural and other sources. If the background level is found to be excessive, measures should be taken to reduce it by modifying pollution control systems of the existing sources. The new pollution control units of the plant should then be designed to contribute only the difference between acceptable value of ground level concentration and the background level already existing.

**20.2** In each iron and steel plant, independent pollution monitoring facilities should be provided. A systematic record of emission inventories and ground level concentrations in residential location at predetermined grid points [ *see* IS : 5182 ( Part 14 )-1979† ] should be maintained by the pollution monitoring group. It is preferable to have a sampling and analysis laboratory and trained personnel for pollution monitoring in the plant itself.

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*Limits for emissions from iron and steel plants.

†Methods for measurement of air pollution: Part 14 Guidelines for planning the sampling of atmosphere (*first revision* ).

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